SIMULATIONS: CHANGING THE PARADIGM FOR OPERATIONAL TESTING

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Introduction

Although May 2000 was ordinary by most standards, it was extraordinary for the U.S. Army Operational Test Command's Air Defense Artillery Test Directorate. During the PATRIOT Advanced Capability-Phase 3 (PAC-3) Limited User Test (LUT) conducted at Fort Bliss, TX, simulation was the main vehicle in an air defense operational test. Over the course of approximately 4 weeks of testing, crews of the test player unit, the 2nd Battalion, 1st Air Defense Artillery Regiment, engaged multiple simulated air breathing threat (ABT) and tactical ballistic missile (TBM) targets in 120 realistic threat air battle scenarios. During this phase of operational testing, not a single live aircraft or missile took to flight. At the same time, however, all testing was effective in terms of data adequacy and cost reduction. In fact, with simulation at the helm via the PAC-3 Mobile Flight Mission Simulator (MFMS) test tool, the cumulative cost of creating and engaging the enemy totaled approximately $600,000—less than the cost of firing a single PATRIOT missile.

The MFMS Tool

At first glance, the MFMS appears to be an ordinary military vehicle, but its capabilities extend far beyond that. The PAC-3 MFMS is a hardware-in-the-loop test system for PATRIOT that can simulate a variety of enemy air vehicles through pre-programmed threat air battle scenarios. These threats include various types of TBMs, ABTs, and air-to-surface missiles. The threat targets have programmable arrival times and designated ground impact points that require the PATRIOT system to engage multiple targets simultaneously. The scenarios are not a random generation of targets but rather a true-to-life representation of known PATRIOT threats across the globe. This feature significantly increases the realism factor of the air battle in each developed scenario.

While the mobility aspect of the simulator is relatively new, the origins of the system are not. The Raytheon Corp. PATRIOT Program Office originated the flight mission simulator (FMS) in 1974 to create a tool for engineering and development. Eventually, Raytheon intended to use the FMS tool for system developmental testing. The goal was to exercise and test the PATRIOT system without altering its tactical configuration. The fire unit equipment was set in normal configuration and connected via the PATRIOT radar to the FMS for artificial target insertion. Initial success came later that year when the first version of the FMS was able to inject radio frequency (RF) signals into the system radar for one simulated target. Within 4 years, the FMS had the capability to stimulate the radar with up to 10 targets. Numerous software and hardware improvements have followed. The test tool is now capable of stimulating the PATRIOT system with the maximum number of targets allowed by the tactical system software.

Raytheon added mobility in 1995 by creating a truck-mounted FMS—this was the evolution of the MFMS. Although engineering, development, and testing were the original goals of the FMS, this mobility allowed increased flexibility for use in operational testing. After an extensive verification, validation, and accreditation process, the MFMS was certified as a viable test tool.

The engagement control station (ECS) is tactically hard-wired to the radar set (RS), and the RS is hard-wired to the MFMS. Additionally, the communications relay group (CRG) van is linked by wire to the ECS. The Information Coordination Central communicates with the ECS via the tactical PATRIOT Digital Information Link and communicates with the Communications, Control, and Command Engineering Environment System (a communications simulator) via Tactical Digital Information Link-J (TADIL-J). This emulates a joint defense network and ensures the system is capable of communicating in a joint environment via the TADIL-J messaging system.

The Battery Maintenance Center wires into the ECS to collect system maintenance and status data via its remote maintenance monitor on the PATRIOT Automated Logistics System computer. Simulating the PATRIOT launching stations are two data transfer units (DTUs). One DTU in the ECS simulates local launchers. The other DTU, located in the CRG, simulates remote launchers which, in reality, may be located 10-30 kilometers from the rest of the fire unit.

To create the scripted targets for each scenario, the MFMS stimulates the RS by inserting the RF signals necessary to emulate an actual track of that type

Mobile Flight Mission Simulator

in the RS search sector. When the radar is operating in "active radiate" mode, a combination of both MFMS-generated and real tracks will appear on the PATRIOT man stations (operator scopes). Visually, the graphic representations of MFMS tracks are no different than those of actual tracks. The operator can differentiate between real and simulated tracks by observing the identification friend or foe (IFF) response of the track if it has a working IFF system. Simply stated, a real aircraft will generate an interrogation response, whereas the simulated aircraft will return no response.

PATRIOT radar and MFMS configured for operation

Why Simulation?

Testing of any new or upgraded system entails two inevitable requirements. First, testing must accurately mirror the system's operational environment as it would exist during a wartime mission. Second, and perhaps more challenging, is that the first requirement must support the data collection required for system evaluation and the corresponding test schedule. In the case of the PAC-3 system, the absolute best test environment would be one of multiple live TBM, ABT, and ASM targets in flight while being tracked and engaged by a mix of live PATRIOT missiles (PAC-2, Guidance Enhanced Missile, PAC-3, etc.). This meets the first requirement as it mirrors PATRIOT operations in a wartime environment. The stumbling block is that costs would be monumental. With live missiles and aircraft flights as costly as they are, simulation is the natural alternative. Additionally, the continued proliferation of threat TBMs since Operation Desert Storm makes the development of accurate threat representative targets even more costly and challenging. The one simulation tool that effectively satisfies much of the two operational testing requirements for PAC-3 is the MFMS.

The Bottom Line

The basic costs between a live PATRIOT missile firing and use of an MFMS differ immensely. Based on PAC-3 FY01 live-fire test projected costs, the funding required to fire a single PATRIOT missile at White Sands Missile Range, NM, is approximately $2 million plus the cost of the interceptor and target. This primarily includes firing range time and equipment maintenance. Because of the close proximity of White Sands to Fort Bliss, equipment transportation is not costly. However, live missile firings at alternate locations, such as the Kwajalein Missile Range in the South Pacific, require up to three times the funding because of increased transportation and range operation costs. Additionally, the following factors cause overall costs to rise even further:

- Research and developmental testing of the target missile flight profile,
- Multiple types of target missiles and target aircraft required,
- Extensive aircraft flying time required, and
- Significant wear and tear on the system as a result of live-missile firings mandate extra repair parts and maintenance personnel.

Based on PAC-3 LUT figures, the cost of one MFMS scenario with 8 to 30 simulated target engagements is approximately $45,000. This includes operational costs of the equipment and creation, verification, and validation of the scenario for target adequacy. Significant resource conservation is a direct result of factors such as the following:

- Simpler and more cost-effective verification and validation of target flight profile for both missiles and aircraft; threat missile motion modeling is easier than reproducing a real flying vehicle.
- Significantly less system wear and tear and maintenance personnel requirements.
- No physical reloads.
- No flying-time requirements.

Lessons Learned

The success of PAC-3 LUTs reinforces the feasibility of simulation in operational testing. The MFMS test tool allows for required data collection and enables conservation of multiple resources. With test costs always a factor throughout the projected fielding and evaluation of any system, funding consistently weighs heavily on the mind of any test officer. The MFMS has demonstrated a proven capability to correctly simulate the flight of threat aerial vehicles that allows the operational tester to collect system performance data. Additionally, the only critical limitations of the MFMS are the inability to simulate clutter and to stimulate more than one fire unit at a time. The FMS is also unable to adequately simulate missile performance and lethality, thus necessitating hardware-in-the-loop, a flight test program, and other performance analysis tools. Despite these shortcomings, it is an outstanding tool that has lifted strains on funding, personnel requirements, and man-hours for the PATRIOT system. The contributions of the MFMS will allow for continued usage as a paradigm of a successful operational testing alternative.

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